NATIONAL FOREIGN INTELLIGENCE COMMUNITY SUPPORT

FOR

ASSESSMENT OF PERSIAN GULF ENVIRONMENTAL DAMAGE

20 June 1991

ICS 3641-91

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Executive Highlights

- This report to the Congress conveys the findings of an Intelligence Community task force established expressly to evaluate the capabilities of National Foreign Intelligence Program (NFIP) assets to contribute to US Government assessments of the nature, impact, and extent of environmental damage resulting from oil fires and spills in Kuwait.

- Director of Central Intelligence priorities that guide the Community's collection and analytic efforts are consistent with the high-level of interest US policymakers have expressed in environmental damage from Iraqi sabotage of Kuwait oil facilities.

- The task force concludes that the fires are presently of foremost concern, and that the most immediate requirement of environmental scientists and analysts is for systematic collection of data pertaining to rates of emission and combustion, and the chemical composition of the pollutants which result.

- Computer models used to simulate and project dispersion patterns for atmospheric pollutants are available to, and have been applied to, the Kuwaiti problem by both the Central Intelligence Agency and the Department of Energy, Sandia National Laboratories.

- The task force ascertained that the NFIP possesses no unique collection resources able to quickly resolve the existing uncertainties over both the quantities and the qualities of burning oil from the Kuwaiti fields.

- Community analysts do believe, however, that meticulous study of data collected by civil satellites and national technical means will eventually produce accurate estimates of the rates at which oil has burned, and the amount. Technically innovative collection concepts have been proposed, and are being evaluated within the Community, which would enable intelligence sensors designed for other purposes to be applied in ways which might abet this process.

- It is uniformly agreed that resolving uncertainties over the chemical composition of the products of combustion from Kuwaiti wells requires systematic, near-source sampling within the oil fire plumes. Existing NFIP aerial sampling assets were found unsuitable for that purpose.

National Foreign Intelligence Community Support for Assessment of Persian Gulf Environmental Damage

Background

Congress, in a passage contained within the Persian Gulf "Dire Emergency" supplemental appropriations bill, strongly urged the Director of Central Intelligence to review capabilities embodied within the National Foreign Intelligence Program (NFIP) in order to identify and employ those systems and resources which might be applicable to supporting US Government assessment of the environmental and ecological damage resulting from Iraqi sabotage of Kuwaiti oil facilities.

An interagency Intelligence Community working group was formed and convened to determine the status and objectives of US Government activities already under way and the needs and priorities of the engaged scientific community. National Foreign Intelligence Program (NFIP) resources and capabilities were reviewed to determine what has been done and what else might be done to assist in US Government assessment of the nature, impact, and extent of the damage resulting from the Kuwaiti fires and oil discharges. New lines of communication with other US Government agencies studying the Kuwaiti problem were opened, adding to regular contacts already taking place. This paper, prepared in both classified and unclassified versions, constitutes the report that Congress has requested.

Other Expressions of Interest and Concern

Congressional interest in utilizing intelligence capabilities for damage assessment of the extreme pollution event in Kuwait was subsequently broadened to embrace support to environmental research in general. Senator Boren, Chairman of the Senate Select Committee on Intelligence, endorsed and forwarded to the DCI a letter from Senator Gore, of the Senate Armed Services Committee, recommending that actions be taken to begin discussion between intelligence officers and environmental scientists to investigate ways and means by which intelligence data collected for other purposes, but nonetheless potentially useful to environmental scientists, might be shared.

Concurrently, within the Executive Branch, the Assistant to the President for Science and Technology was emphasizing to the Department of Defense the research importance of the Kuwaiti oil fires in better understanding atmospheric processes and improving prediction of human health risks, and requesting that DoD continue its assistance toward meeting those goals. Similarly, the Senate Armed Services Committee was encouraging routine DoD involvement in environmental issues by way of a Strategic Environmental Research and Development Program. Thus, with the initiation of the DCI's Congressionally directed review, those components of the NFIP which are organizationally vested within the Department of Defense have been responsive to dual avenues of inquiry concerning capabilities--primarily, collection capabilities--which could be applicable to the class of environmental problems for which the Kuwaiti experience serves so dramatically as case in point.

Early Community Response

Sensing a mounting interest among US policymakers in environmental matters, the CIA Directorate for Intelligence established an Environmental Issues Branch (GRD/EIB) two years ago--well in advance of the acute pollution episode which was to occur in the Persian Gulf. Initial emphasis was placed on the political and economic aspects of environmental issues. Within the Office of the President, reports and briefings on these issues have been provided to council chairmen, special counsels and assistants, and the Office of the US Trade Representative. During its brief tenure, CIA's Environmental Issues Branch has responded to policymakers at all levels in the Departments of State, Treasury, Commerce, Energy, and the Environmental Protection Agency.

At the broader community level, the Foreign Intelligence Priorities Committee of the Intelligence Community Staff (ICS/FIPC) was also responding to a sense of shifting interests among policymaking consumers of national foreign intelligence. In 1990, a major review was undertaken of "US Foreign Intelligence Requirements Categories and Priorities," the document which sets forth the DCI's basic substantive guidance to the Community for the operation, planning, and programming of the overall US foreign intelligence effort. Among the many revisions that this review produced was creation of a new subject category on health and the environment. Kuwaiti oil fires and slicks were subsequently assigned a high priority within this new category.

Direct Intelligence Contributions

In the building momentum of planning for Operation DESERT STORM, the possibility that the about-to-be evicted Iraqi intruders, turned vindictive, might use oil as a defensive weapon was not overlooked. In response to the threat this prospect might hold for both the well-being and tactical effectiveness of coalition military forces, a couple of important activities were initiated.

Sandia National Laboratory, under the auspices of the Office of Foreign Intelligence, Department of Energy, formed a multidisciplinary team to provide preliminary potential optical effects, ecological stresses, and reservoir damages that would result from the demolition of wellheads in Kuwait oil fields and from the discharge or ignition of oil from nonreservoir sources such as oil storage tank farms, man-made oil-filled trenches, pipelines, and oil tankers. Best-case and worst-case scenarios for the oil fields were considered. The approach in this study was to perform a series of time-phased analyses, each stage of which generated not only immediate results, but also the requisite inputs, or source terms, for the succeeding stage. For example, reservoir analyses provided source terms for combustion analyses in addition to estimates of reservoir damage; combustion analyses defined combustion products, posed oil-filled trench issues, and provided source terms for atmospheric processes; atmospheric analyses generated potential optical effects and provided source terms for ecological analyses that, in turn, provided estimates of ecological stresses.

Also, within the Central Intelligence Agency (CIA), a fast-track initiative was undertaken to adapt an existing contractor-developed, multidisciplinary, atmospheric dispersion computer model to the Persian Gulf threat. The resultant plume model produces tactical forecasts of soot and other pollutants in the air at ground level from which short-term impact on human health can be projected more than two days in advance. The model has been further applied to estimating the cumulative effect throughout the Middle East and adjoining regions of extended exposure to combustion products generated by the Kuwaiti fires. Projections so derived comprise the central thrust of the analyses currently under way at CIA. Again, human health is of major concern, and CIA's Office of Medical Services (OMS) is a regular participant in analyses of the toxicological implications of pollution from the Kuwait fires. Other ramifications such as agricultural production are also receiving analytic attention.

As Iraqi destruction of Kuwaiti oil facilities moved from prospect to fact, attention initially focused on the oil slick and assessing the oil slick threat to Saudi desalinization facilities became a foremost concern. The Remote Sensing Applications Staff (RSAS) at CIA was called upon to develop and apply unorthodox new imagery sensing techniques to this problem on a priority basis. Using civilian satellite (AVHRR) multiband imagery, RSAS was able to determine and describe the location, movement, and dispersion of the Gulf oil slick weeks earlier than it could be tracked by teams operating within the region. This early tracking facilitated planning and activation of preventive measures, such as positioning of booms to protect sea water intakes, as well as the subsequent cleanup efforts which were led by the US Coast Guard. The information also allowed a running start for the oil slick monitoring activities of the National Oceanographic and Atmospheric Administration.

While the environmental damage from oil discharges into the Persian Gulf was by no means trivial, the extent of the damage never reached the proportions to which the Iraqis aspired. Clearly, where pollution is concerned, the proverbial "ounce of prevention" is indeed worth a pound of cure. In truncating, quickly and precisely, Iraq's capability to pump Kuwaiti oil into the Gulf, US military forces provided the prevention that was needed. And the Intelligence Community, in contributing to the detailed targeting information that was needed to execute US preventive air strikes successfully, played a significant role in containing Iraq's attempts to pollute Gulf waters.

Later, as the threat from oil slicks waned, focus shifted to the smoke plumes from the oil well fires. On both points, slicks and plumes, imagery and maps using the new techniques evoked a strongly favorable response from senior US Government officials, as well as from concerned analysts both within and beyond the Intelligence Community. Application to the oil fire smoke plumes of the same techniques used against the slicks was able to provide US policymakers, scientific analysts, and the American public with unprecedentedly graphic evidence as to massive oil field damage and the scope of the spreading smoke.

The bulk of CIA's effort has been invested in developing and applying their plume model. Both CIA and DOE continue to seek data in an effort to improve upon the validity of their modeling projections. CIA notes that, in its present form, the computer model it has employed has substantial growth potential in being amenable to steady refinement to improve predictive capabilities as additional field measurements become available. If additional resources were made available, CIA would apply the funds to further validate the computer model on which its analysis is based and acquire additional LANDSAT imagery--which has also figured importantly in CIA's work to date.

The DOE analysis, which follows up on the Department's earlier work in estimating the regional toxicological threats, has three closely related thrusts: dispersion (plume) modeling, health effects projection, and a monitoring program. The dispersion model used in the DOE study was developed under contract to the Environmental Protection Agency, and is widely used for estimating pollutant concentrations. The health effects projections were synthesized from EPA's National Ambient Air Quality Standards and from a National Academy of Sciences study on particulate polycyclic organic matter. DOE's monitoring program has been designed to address the significant levels of uncertainty associated with the dispersion model calculations. This uncertainty is due principally to uncertainty in emission factors. Implementation of a properly designed monitoring program will reduce these uncertainties. Health effect projections are also replete with uncertainties at least as significant as those associated with the dispersion model. Consequently, in DOE's view, acquisition of acute health effects data (e.g., hospital census data) should be an integral part of a monitoring program.

The Immediate Need: More and Better Data

Scientists have viewed the Kuwaiti oil fires as providing an opportunity for an unplanned, large-scale experiment, and stressed the importance of seizing the opportunity to advance scientific understanding of both atmospheric processes and health effects. The purpose of an experiment is, of course, to make observations: to generate and record data which can then be used to (1) identify the things that matter, (2) describe how these variables relate one to another, and (3) test the relationships to be sure they are correct. However tightly reasoned and insightful an analysis may be, absent data it must retain a flavor of supposition.

Within the scientific community studying the Kuwaiti fires, general agreement is manifest on two very basic points. The first regards analytic approach. There is a broad endorsement of the essential importance of computer models in projecting patterns of dispersion, exposure, and transfer; considerations which are in turn prerequisites to further analyses. This consensus on methodology applies to a wide range of atmospheric pollution events; from a Bhopal to a Chernobyl; a Mount St. Helens to forest fires, whether in Yellowstone Park or the rain forests of Brazil. Numerous such models have been constructed, and each has won its set of analytic proponents. The analytic problem is that the results often diverge, and there is no way to know why until more information about the Kuwaiti fires is recorded. Hence the second point of consensus: data is surely needed, first to better define "parameters" (i.e., the "inputs" upon which all computer models feed) and then to establish the accuracy or lack thereof of the projections a model is producing (i.e., to test the "outputs").

This is the generic opportunity environmental scientists have seen in the Kuwaiti fires: the chance to acquire data which could lead to advances in understanding for a whole class of pollution events. Until that is accomplished, it becomes difficult to envision how a productive dialog over the myriad of substantive issues might unfold. In the argot of intelligence, first and foremost, environmental scientists face a "collection problem."

Collection and sampling requirements against the Kuwaiti fires, as set down by the DOE's Sandia National Laboratory, are presented in the Attachment. These requirements have been reviewed by CIA and others and--modified only to include determination of thermal properties, such as flame temperatures and heat release rates---may be interpreted as reflective of common needs across the environmental analysis community. Logically, the kinds of data that are needed to improve present abilities to project dispersion patterns--which is in turn prerequisite to sound assessments of the ultimate toxicological, climatological, or ecological implications of the event--fall into three categories:

(1) Meteorological Conditions
(2) Source Emission Factors
   - Quantitative (rates and amounts)
   - Qualitative (composition)
(3) Down Plume Conditions

Measurement of meteorological conditions and emission factors (i.e., how much oil is burning, where, and what precisely is the chemical composition of the products of this combustion) provide inputs to the computer models. Down-plume measurements are necessary to verify the accuracy of the projections the models are producing and provide a basis for methodological refinements aimed at improving forecasting accuracy.

One fundamental need for emissions data pertains to the rate at which oil is burning. CIA has estimated the initial overall capacity of the Kuwaiti wells to have been on the order of four to six million barrels per day. This set an initial, worst-case upper limit on the amount of oil that might be afire. As yet, however, there is no solid, empirically derived estimate as to how much oil is actually burning, or how that rate is varying over time. As the wells continue to vent, the natural pressures which drive emissions lessen. And, of course, wells are gradually but steadily being extinguished and capped. Millions of barrels of oil are still burning each day, but it has yet to be determined just how much.

Potential for Further Intelligence Contributions

Review of existing NFIP capabilities has revealed no unique intelligence means by which to quickly resolve the analytic impasse over emissions data. Intelligence sensors are for the most part highly-sophisticated devices specialized for purposes distinctly different from that of measuring the parameters of the Kuwaiti fires. Although US intelligence has no "breakout" data collection capabilities against the Kuwaiti oil fires, work is under way and new ideas have emerged--some quite unorthodox and innovative--that may provide information of considerable value to US environmental scientists.

As noted above, substantial uncertainty exists over the amount of oil that is burning in the Kuwaiti fires, and a second critical set of unknowns is the composition of the contaminants that the fires are producing. DOE considers this uncertainty over qualitative "emission factors" to be the most significant source of estimation error in its analytic work to date. CIA, which has sponsored some test burns to generate the emission factors that its model employs, also places a high-value on acquiring better data about the composition of the products of combustion at the several Kuwaiti fields. Specific emphases of analysts vary somewhat according to which particular computer model they are working with, but generally interest centers on soot (both amount and granularity), oxides of nitrogen and carbon, sulfur dioxide, and benzene.

Gathering these data, which are so sorely needed to advance scientific understanding, presents a formidable--and indeed dangerous--collection challenge. Scientists agree that samples must be taken as near as possible to the sources of combustion, which means entering the very heart of the smoke plumes--not once or twice, but repeatedly in accordance with a carefully worked out, statistical valid sampling plan. Moreover, since the merging of plumes may alter the chemistry of the pollutants, measurements from individual well fires will need to be complemented with samples taken in areas where plumes are joining together. So far, acquiring the qualitative "source-term" data analysts seek has proven an elusive and frustrating task. Only a few samples of near-source emissions have been acquired.

Inasmuch as low altitude flights directly into the oil fire smoke plumes, whether with fixed wing aircraft or helicopters, inherently pose substantial risk to crews and aircraft, Air Force intelligence has proposed the use of unmanned systems to penetrate the plumes and collect the samples which analysts need. Several options are being weighed, all of which would employ one or more remotely activated sampling bottles aboard an unmanned carrier. One alternative would be to use a modified military RPV--Remotely Piloted Vehicle. But at a cost of $10,000 to $50,000 apiece, use of RPVs for any extensive sampling program could become prohibitively expensive unless it is assumed the vehicle would be routinely recovered and reused. Under the scientifically ideal case wherein collections would be made right at the flame-smoke boundary, this assumption could prove unfounded.

A second complication, common to any sampling approach that involves complex, close-in launch or retrieval operations from the ground, lies in the danger of conducting such wide-ranging activities in the immediate vicinity of the damaged oil fields. A clear threat to the safety of sampling teams remains present in the combination of unexploded munitions, oil-soaked terrain, and the heat, fumes, and curtailed visibility resulting from the fires themselves. Although it is to be emphasized that these unmanned air sampling options represent ideas, not fully evaluated concepts--much less existing capabilities--the Air Force is prepared to pursue further investigation, tests, and demonstrations, if so directed and funded.

Data Requirements and Sampling Overview: Kuwait Oil Fires

Meteorological Measurements

Collect data hourly (as is done routinely by airport weather services) or as needed (i.e., more frequently if hourly data show large changes) at altitudes, latitudes, and longitudes appropriate for correlating with source-term, downwind airborne, satellite, and ground-based measurements. Data include:

- Wind direction and windspeed
- Ambient temperature
- Humidity
- Pressure
- Visibility
- Sky condition (cloud cover)
- Solar insulation
- Weather

Source-Term Measurements

Collect data for individual (single wellhead) plumes using airborne collection platform, satellite imaging, and well site measurements. Data collection modes should be coordinated in time. At least twice daily sampling using:

- Airborne Measurements
  - Plume injection height; plume cross-sectional area (using lidar)
  - Speed and direction of motion of plume
  - Primary pollutant[1] concentrations and emission factors (develop data base for using soot as a tracer, i.e., to infer concentrations of other pollutants from that for soot)
  - Optical properties, such as scattering and absorption coefficients (to tie together satellite image and soot concentration).

- Satellite Measurements
  - Locations of sources and a real extent
  - Images from which to infer soot concentrations

- Well Site Measurements (check for consistency with airborne data)
  - Oil/gas flow rate
  - Oil/gas composition (in particular, carbon content)

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[1] Primary pollutants are generated at the burning wells and include soot, H_2S, NO_2, SO_2, CO, CO_2, and volatile hydrocarbons. Other, secondary pollutants are then generated by the reactions of primary pollutants in air.

Downwind Plume Data

- o Downwind Ground-based Measurements (monitor ground-based exposure levels)
  - Pollutant concentrations (including secondary pollutants)
  - Particle geometry and size distribution (soot)
- o Downwind Airborne Measurements (validate model predictions; correlate with satellite data)
  - Pollutant concentrations (including secondary pollutants)
  - Plume orientation and dimensions
- o Satellite Measurements (tie in with airborne data, establish feasibility of routine use of satellite imaging in infer tracer, i.e., soot, concentrations; note that, potentially, archived images may be examined to infer concentrations at early well burning times for which no other data are available)
  - Soot concentrations
  - Plume orientation and dimensions

Sampling Design

Statistical Experiment Design

- o Ground-based, receptor site Measurements
  - Using existing receptor sites (viz, the existing USIAAT sites) and data to obtain a preliminary estimate of the spatial variability of the pollutant dispersion process.
  - Using this information, determine the number and location of additional receptor sites that would provide a significant improvement in the measurements; perform cost/benefit analysis.
  - In general, receptor network design should provide for continual monitoring along transects that run perpendicular to the expected path of the plume and at sites located (whenever possible) within population centers.

- o Airborne Measurements
  - For source-term measurements, select the wells to be sampled by random sampling of burning wells within each major oil field (stratified random sampling approach); sample size for each field will be determined using statistical method for sample size determination (e.g., representative sample method: if 38 well plumes are sampled in a field then one can be 90 percent confident that 90 percent of the true values of a measured quantity will fall within the range of the smallest and the largest measured values).

- Expect selected statistical experiment design to be modified somewhat by operational considerations such as aircraft availability, allowable flying time, safety considerations, visibility, accessibility of single plumes, etc.
- In general, sample by flying transects above and within plume at near-field (for source-term data) and far-field (for downwind plume data) locations.

Parameter Estimation and Model Validation

- o Examine a number of dispersion models that possess certain commonalities with respect to the modeling parameters (e.g., pollutant emission factors, oil/gas flow rate, plume injection height, windspeed and direction, etc.) that are used and focus on those input parameters that most sensitively affect predicted pollutant concentrations.
  - Provide estimates of these input parameters (estimated using appropriate measurements; e.g., meteorological data and source-term data that serve to define physically realistic ranges of values for these parameters) to each model and compare predicted concentrations to measured concentrations; use criterion such as minimization of mean square error to assess quality of each simulation.
  - Change values of input parameters (but keep within physically realistic range) and run dispersion simulations. Repeat this process noting which model provides best results over the parameter space (i.e., over the range of physically realistic values for the parameters).